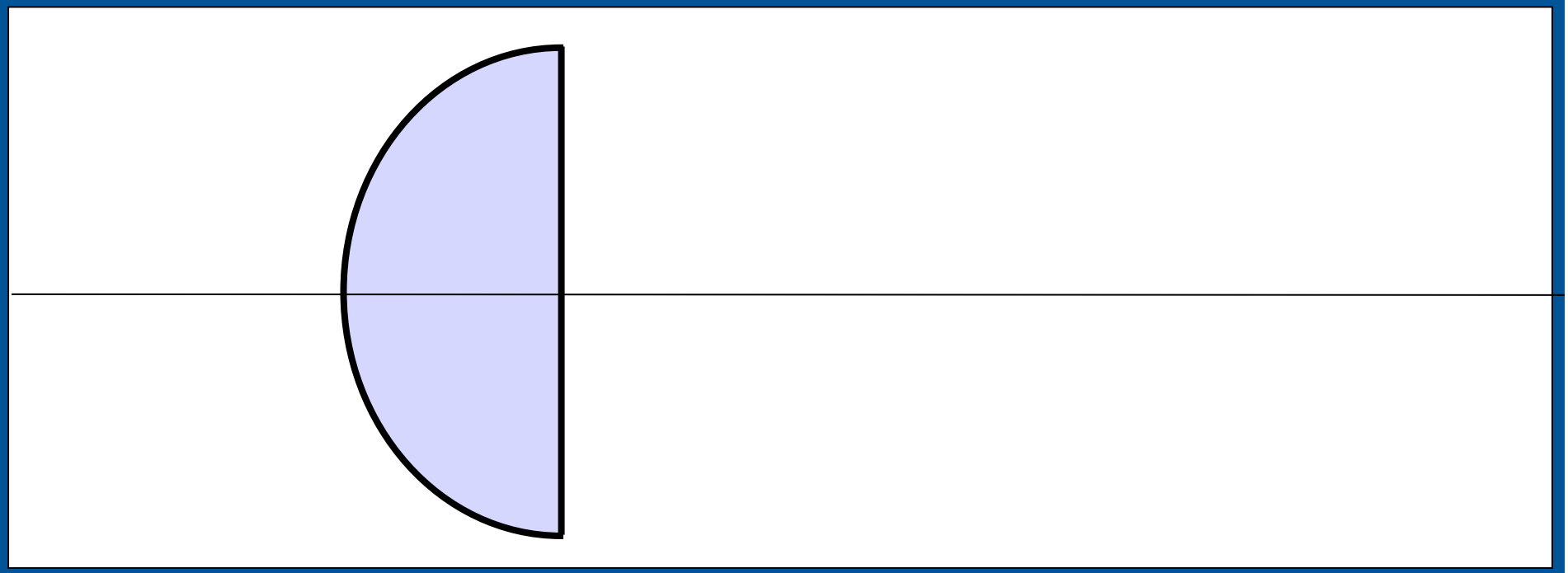
# The lenses of the microscope

The important lenses of the microscope are *positive* or *converging* lenses,

- thicker in the middle than at their edges



# The job of an ideal lens

- To accept as many rays as possible from each point in an object
- To reassemble all the rays from each point at corresponding points in the image…
- In such a way that the distance travelled by all the rays from each object point to its corresponding image point is the same
  - so that they all arrive ‘in phase’.

This is unfortunately not possible with a single-element lens
because of several *aberrations*
- spherical, chromatic and others

# A lens has two focal points


Rays entering lens parallel...

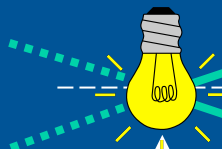
Focal point

...are converged on the opposite side of the lens

as with a camera

Rays entering lens through a focal point...

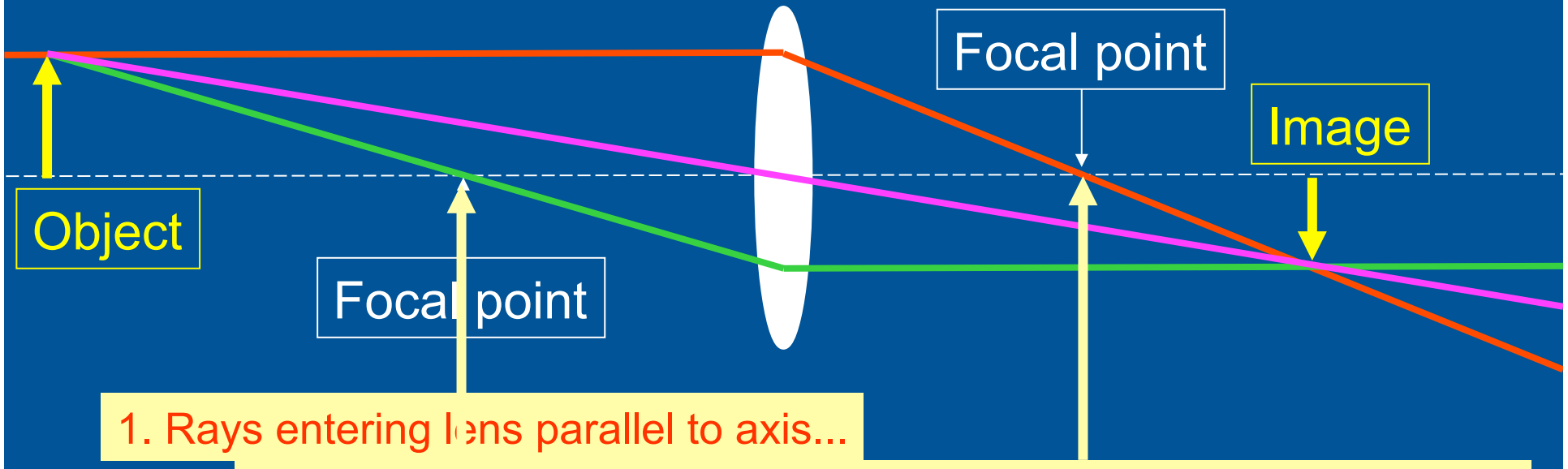
…emerge parallel on the opposite side of the lens



Focal point

as with a projector

# Ray diagrams - three simple rules



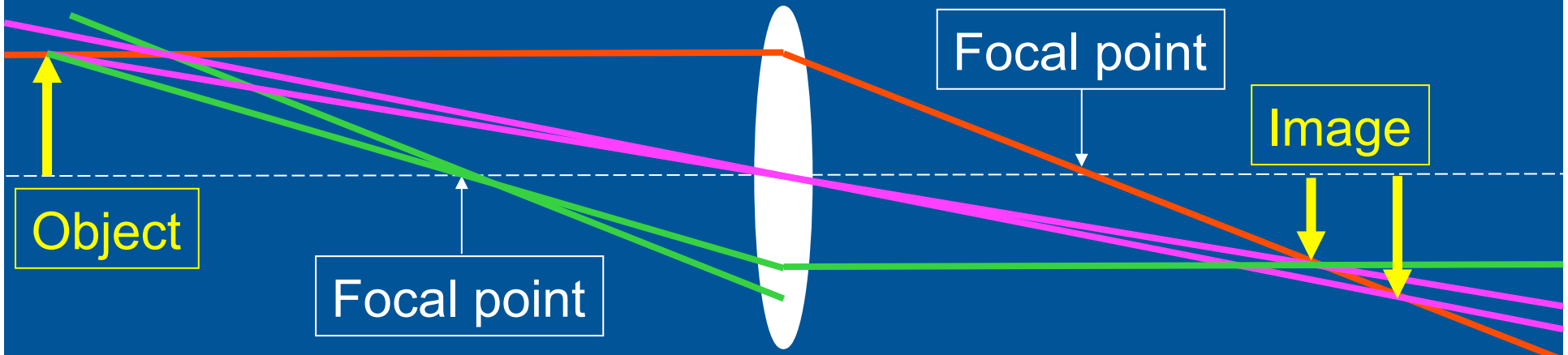

1. Rays entering lens parallel to axis...

… cross the axis at the focal point on the opposite side of the lens

2. Rays entering lens through focal point... leave the lens parallel to axis

3. Rays passing through centre of lens are undeviated

# Object moved closer to lens:
# Image moves further away on opposite side




1. Rays entering lens parallel to axis...

… cross the axis at the focal point on the opposite side of the lens

2. Rays entering lens through focal point... leave the lens parallel to axis

3. Rays passing through centre of lens are undeviated

# What can lenses do??

Lenses can act in a way similar to those of three familiar optical devices:

## Camera

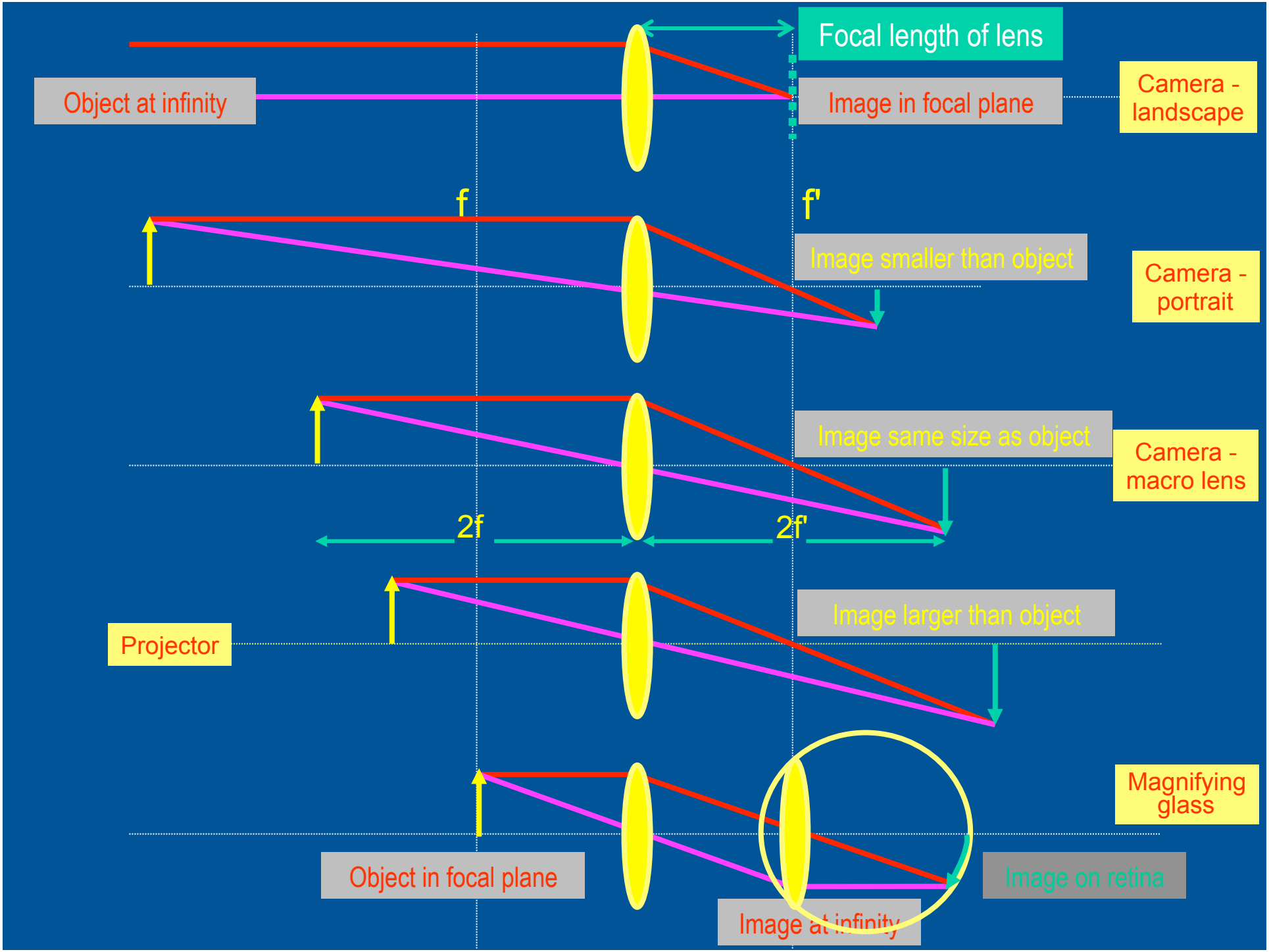
- forming a reduced-size, real image, close to the lens

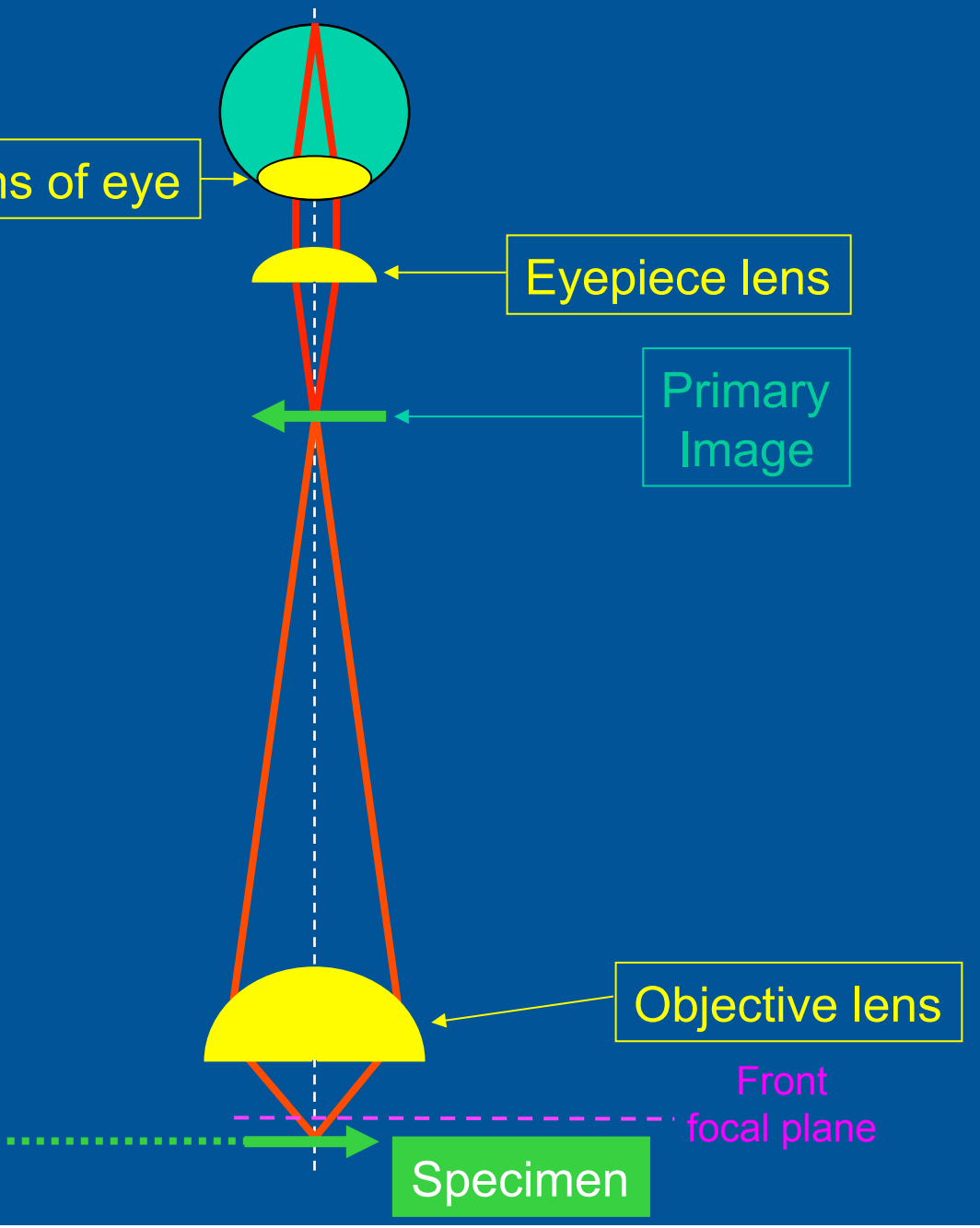
## Projector

- forming an enlarged, real image, distant from the lens

## Magnifying glass

- not forming a real image; parallel rays to infinity


Focal length of lens
Object at infinity
Image in focal plane
Camera - landscape
f
f'
Image smaller than object
Camera - portrait
Image same size as object
Camera - macro lens
2f
2f'
Projector
Image larger than object
Magnifying glass
Object in focal plane
Image on retina
Image at infinity




The objective lens works like a *projector lens* and forms the **Primary Image** 10mm below the top of the viewing tube

and the eyepiece acts as a *magnifying glass* and examines the centre of this image